Development of New Dielectric NDE Techniques for Spaceflight Materials

Completed Technology Project (2013 - 2014)

Project Introduction

Dielectric Spectroscopy is a relatively new technique for nondestructively measuring material properties. The goal for this project is to extend the use of state-of-the-art dielectric spectroscopy systems to measure the spectra of spaceflight materials and develop non-destructive evaluation (NDE) sensors based on dielectric material properties. This work may lead to a new class of material density, moisture, temperature, and defect sensors providing structural integrity and health measurements for future spacecraft and launch structures.

Dielectric spectrometry will be performed on select spacecraft materials (i.e. heat shield materials, structural materials and insulating foams) to examine their capacitance and permittivity under controlled humidity. Three types of samples will be tested for each selected material, a dry, defect free sample, samples with known defects and moisture levels, and samples of unknown condition as a test of validity. Tests will be conducted from three microhertz to three gigahertz at temperatures ranging from -160°C to 400°C in order to obtain a full dielectric profile. The complex dielectric spectra acquired will be analyzed using computational modeling in order to determine the fit parameters associated with that material. These dielectric spectra and computational models will be used as the basis for proposals for new capacitance three-dimensional permittivity mapping sensor systems for monitoring structural health, extending a material's lifetime in high humidity environments (like those of Florida) and in forming improved repair processes.

A Novocontrol Concept 80 Broadband Dielectric Spectrometry system will be used to measure the complex dielectric spectrum for select spaceflight materials. Samples with known defects will be measured to serve as a comparison to known good samples. Materials that are known to have problems with moisture absorption will be measured after exposure to different moisture levels to see how the complex permittivities vary with moisture content.

Analysis will be performed on the spectra to determine the extent to which damage and moisture can be quantified for each of the materials. Concepts for new NDE techniques and sensors will be proposed based on the results of the analysis. Materials targeted to be tested include heat shield materials, such as Phenolic Impregnated Carbon Ablator **(**PICA), Avocat, and high performance polymers.

Anticipated Benefits

KSC is using two Novocontrol Broadband Dielectric Spectroscopy systems to characterize the dielectric properties of spacecraft materials over a broad frequency range. Measuring the spectra of these materials over such a wide range of conditions will likely show "fingerprints" to help distinguish material problems such as structural degradation, and moisture uptake. These

One of two Novocontrol Concept 80 Broadband Dielectric Spectroscopy Systems

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"fingerprints" would serve as a basis for developing new sensing and visualization techniques based on capacitance or impedance measurements. This will help alleviate the lack of existing non-destructive evaluation (NDE) techniques for detecting moisture absorption and certain structural defects in these types of materials.

The majority of the materials under study are not specific to any one program. However, the Avcoat material is presently being used as the Orion heat shield. As a minimum, the data collected should help the NDE community reduce the time to characterize a defect for the materials in this study.

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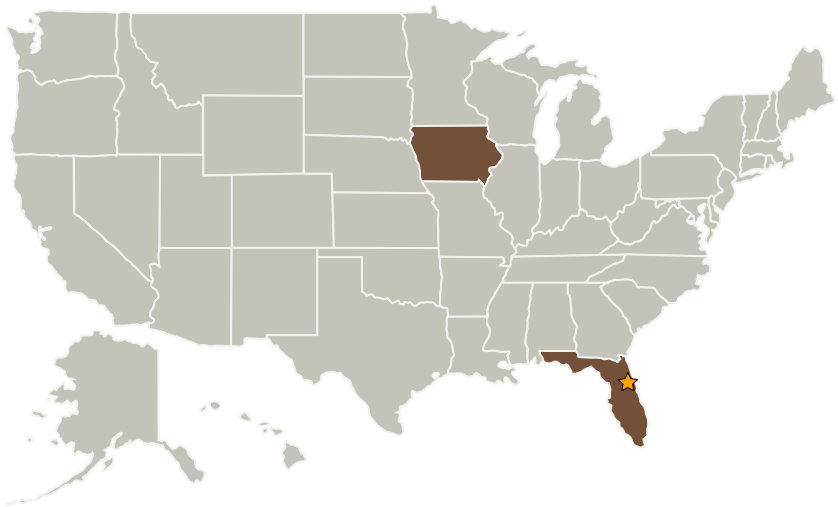
GSDO, MPCV, SLS, & Commercial Crew programs will all be using materials that can degrade when exposed to the moist Florida environment. Sensing techniques will be needed to ensure moisture levels remain within the design tolerances after exposure.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Center Independent Research & Development: KSC IRAD

Project Management

Program Manager:

Barbara L Brown

Project Manager:

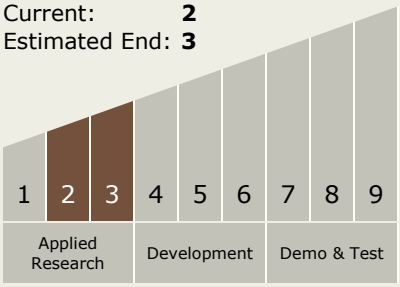
Mark A Nurge

Principal Investigator:

Robert C Youngquist

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



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Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
Iowa State University	Supporting Organization	Academia	Ames, Iowa

Primary U.S. Work Locations	
Florida	Iowa

Images

Novocontrol Concept 80 Broadband Dielectric Spectroscopy System
One of two Novocontrol Concept 80 Broadband Dielectric Spectroscopy Systems
(https://techport.nasa.gov/image/2858)

Technology Areas

Primary:

- TX14 Thermal Management Systems
  - TX14.3 Thermal Protection Components and Systems
    - TX14.3.1 Thermal Protection Materials